



On the need of Hybrid Intelligent Systems in Modular and Multi Robotics

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- Modular robotics
- Multi-robot systems
- Concluding remarks



Introduction

- New task features
 - Highly dynamic unstructured environments and
 - The tasks to be performed are seldom carried out in the same exact way,
- Examples
 - Shipyards
 - Plants for constructing unique large structures



Introduction

- Desired properties of robotic systems
 - Modularity
 - Scalability
 - Fault tolerance
 - Ease of reconfiguration
 - Adaptation
 - Low fabrication and maintenance costs



Introduction

- Multi-robot and modular robotic systems
 - Are naturally modular
 - Scalability can be easily achieved adding
 - Fault tolerance is achieved through distributed control and task/role distribution
 - Reconfiguration is obtained through
 - Individual robot motion
 - Relative positioning of modules



Introduction

- Multi-robot and modular robotic systems (cont.)
 - Can easily adapt to changes in
 - Environment configuration
 - Task definition
 - Fabrication and maintenance costs are linear in the number of components.



Introduction

- Hybrid intelligent systems:
 - Composition of heterogeneous computational tools
 - Knowledge representation: Fuzzy systems, bayesian reasoning, neurla networks
 - Optimization: Genetic Algorithms, Evolutionary Strategies, Artificial Immune Systems, Simulated Annealing
 - Filtering: data reduction, image and signal processing



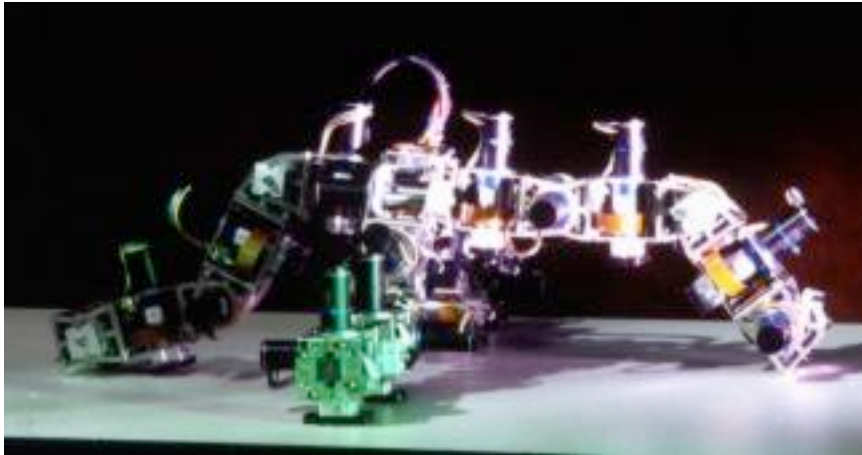
Introduction

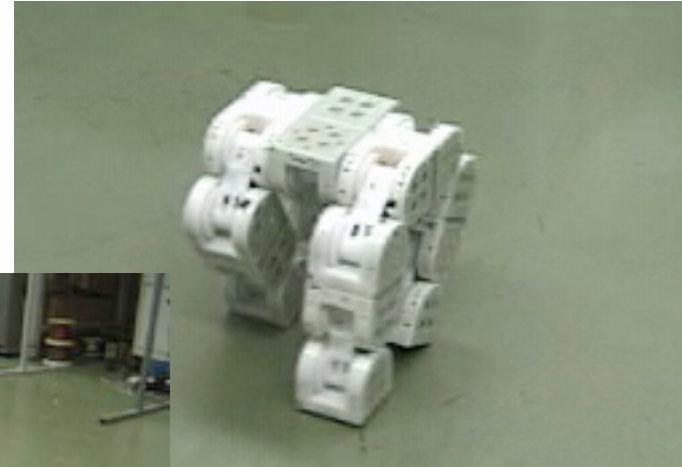
- Composition/decomposition
 - Connected continuous robot
 - Homogeneous:
 - Distributed multi robot system
 - Heterogeneous: task decomposition
 - Distributed cooperative robot
 - Independent robot units
 - They do not require others to fulfill the task
 - Cooperation --> scale, resource optimization



Modular robots

- Robotic structures that are made up of multiple, generally identical, modules
- Cellular automata and social insect theories
- Behavior emergence and holistic principles
- Autonomous (without human intervention)







Modular robots

- Interesting behaviors
 - autonomously self-organize and change their shape in order to adapt to different tasks or classes of terrain
 - potential for self repair: it is possible to eliminate the damaged module and substitute it using another one



Modular robots

- State of the art
 - have achieved their objectives only in very controlled laboratory environments
 - control systems within the modules are created ad hoc for the task to be carried out



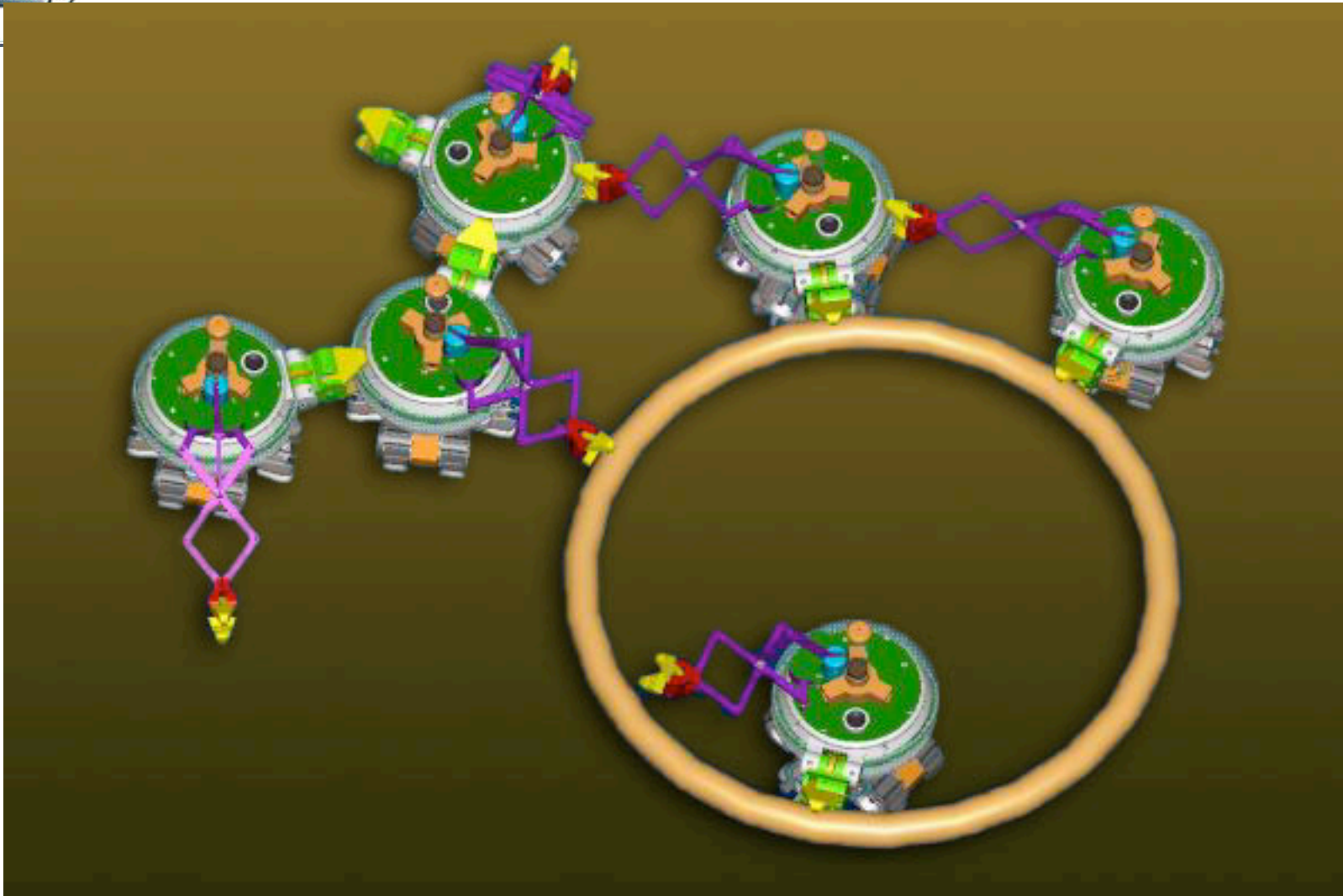
Modular robots

- Potential field for Hybrid Intelligent Systems
 - Autonomous self reconfiguration through state estimation (NNs) and optimal transformation computation (EAs).
 - Evolutionary design of system modules
 - Sensing for
 - Estimation of self configurations
 - Goal attainment



Multi robot systems

- **robot swarms** : groups of robots that collaborate to achieve an objective
 - rescue tasks
 - material handling in flexible fabrication cells
 - the RoboCup
- **Biological foundations**





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Multi robot systems

- State of the art
 - Ad hoc individual logic programming
 - Tailored experimentation for proof of concept (swarmbots)
 - Need of central controller:
 - Perception
 - State estimation
 - Control commands



Multi robot systems

- Potential for hybrid intelligent system
 - Enhance internal individual dynamics with approximate reasoning.
 - Enhance communication between individuals
 - Direct: via signal processing
 - Stigmergy: via intelligent optimization swarm design
 - Sensor information fusion
 - Map building
 - Localization



Multi robot systems

- Potential for hybrid intelligent system
 - Decentralized control strategies
 - Incomplete, temporally inconsistent information
 - Evolutionary approaches



Concluding remarks

- General application potential for HIS
 - Sensing
 - Self-state estimation
 - Distributed Environment Sensing
 - Sensor fusion
 - Control strategies
 - Fully autonomous adaptation
 - Optimal planning